

National Oceanic and Atmospheric Administration
Strategic Research Guidance Memorandum
August 2015

NOAA was established in 1970 “...for better protection of life and property from natural hazards...for a better understanding of the total environment...[and] for exploration and development leading to the intelligent use of our marine resources...”¹ Today, NOAA is the Nation’s premier environmental intelligence agency with a mandate to develop a predictive understanding of processes from the surface of the sun to below the ocean floor. As a science-based services agency, NOAA maintains a research and development (R&D) portfolio that underpins every dimension of NOAA’s mission. Robust R&D is essential for NOAA’s products and services to improve continually in response to:

1. Growing demand for new and improved services;
2. Changes in NOAA’s portfolio of mission needs in response to evolving environmental conditions or directives from the Legislative, Judicial and Executive branches;
3. Emerging understanding of the dynamic Earth system and its ecosystems;
4. Innovations in R&D methods, tools and approaches; and
5. NOAA’s role in cooperative environmental research and management efforts.

This NOAA Strategic Research Guidance Memorandum establishes an overarching framework by which the agency-wide R&D enterprise can be continually reviewed, evaluated and rebalanced in light of the Agency’s evolving mission needs, thus allowing the Agency to implement a portfolio-logic approach to its R&D investment.² “Portfolio logic” refers to a detailed understanding of the full portfolio of NOAA mission needs that require R&D for accomplishment.³ Used effectively, this guidance will foster aggressive decision-making with

¹ 5 U.S.C. app. at 211-12

² This memorandum is based on the following existing doctrine and guidance: NOAA Administrative Order (NAO) 216-115 on Strengthening NOAA’s Research and Development Enterprise, NAO 216-105: Policy on Research and Development Transitions, the NOAA 20 Year Research Vision and the NOAA Five Year Research and Development Plan (2013-2017), recommendations from NOAA’s Science Advisory Board, the results of the NOAA Science Challenge Workshops, the NOAA Plan for Increasing Public Access to Research Results, the NOAA Ecological Forecasting Roadmap and the NOAA Arctic Action Plan.

³ The concept of portfolio management was defined in NOAA Administrative Order (NAO) 216-115 as “the processes, practices, and specific activities to perform continuous and consistent evaluation, prioritization, budgeting, and finally, selection of investments that provide the greatest value and contribution to the strategic interest of the organization.”

regard to investment as well as redirection and divestment within all areas of the NOAA R&D portfolio.

Researchers, technology developers and managers at all levels of the Agency will use this Guidance when reviewing NOAA's R&D portfolio, exploring new research opportunities or determining when a research activity should be expanded, accelerated, shelved or terminated. Beneficiaries of NOAA R&D such as operational entities and resource managers can consult this guidance to deepen their understanding of the logic underlying NOAA's R&D portfolio. Finally, those whose actions influence the NOAA R&D portfolio (e.g. planners, budget formulators, appropriators, evaluators, advisors and external researchers) may use this Guidance to help direct their efforts to influence the scope and direction of NOAA's R&D enterprise. The following framework based in principles will define our R&D enterprise:

Mission alignment: NOAA's R&D portfolio will be focused on NOAA's explicitly defined mission needs, which include "to understand and predict changes in climate, weather, oceans, and coasts," "to share that knowledge and information with others," and "to conserve and manage coastal and marine ecosystems and resources." All participants in NOAA's R&D enterprise will know the specific mission(s) they are supporting with their research or technology development and view each of their activities as directly relevant to (a) specific NOAA mission(s) need.

Transitioning Research and Development: Continually improving NOAA's products and services to meet the needs of the Nation is an integral part of the R&D enterprise. These improvements occur by developing the most promising research, including new or improved observing, modeling and information technologies and the results of field- and laboratory-based process studies to the point that they can ultimately be transitioned into operations, applications, commercialization or other use (R2X). Participants in NOAA's R&D enterprise will characterize their activities in the framework of readiness levels⁴ and will understand the process for advancing their R&D products to a higher level of readiness. This memorandum reinforces the outcomes of the February 2015 NOAA R2X Summit including the development of a NOAA-wide process for prioritizing transitions in which NOAA's Line Office Transition Managers are fully engaged and recommendations for accelerating transitions are approved by the Chief Scientist and Deputy Under Secretary for Operations, with final authority vested in the NOAA Administrator.

⁴ Readiness levels are defined in [NAO 216-105: Policy on Research and Development Transitions](#). NOAA's concept of nine Readiness Levels is based on the Technology Readiness Level concept advanced at NASA, but is not restricted to technology.

Research balance: Meeting NOAA's evolving missions requires a vigorous and forward-looking R&D enterprise that includes a wide range of natural and social sciences. NOAA's R&D portfolio will be balanced across disciplines, across readiness levels, among interdisciplinary foci, between natural and social science, and between short-term and long-term efforts, and will tolerate a degree of risk commensurate with the goal of sustaining and advancing world-class capabilities in support of the Agency's mission needs.

Partnerships: NOAA has a wide range of tools for accomplishing mission-driven R&D by engaging external partners. These include contracts; grants; long-lived Sea Grant, Cooperative Institute and Cooperative Science Center agreements with universities; joint activities with other Federal agencies included those directed by the Office of Science and Technology Policy and in response to larger community initiatives; well-organized "Citizen Science" projects; Cooperative Research and Development Agreements and other arrangements with the private sector; and a variety of nontraditional partnerships such as with tribes, states, Councils and Commissions, non-governmental organizations, and partners within industries affected by NOAA management actions. These tools and arrangements with partners provide considerable flexibility to the NOAA R&D portfolio as well as access to a diverse range of talented personnel. Different approaches to supporting R&D are appropriate for different degrees of maturity in a given area of research and allow for considerable risk tolerance. In evaluating the NOAA R&D portfolio, NOAA leadership will determine what tools, or portfolio of tools, are optimal for which mission need, and adjust the current set of tools to best meet NOAA's evolving mission needs while carefully managing partner expectations. The "CI 21" initiative will focus on how cooperative research within NOAA's Cooperative Institutes Program is best established, conducted, and assessed to meet NOAA's mission priorities moving forward in the 21st century.

Facilities and infrastructure: The complex, transdisciplinary and long-term R&D essential to accomplishing NOAA's missions depends on sophisticated research facilities and hardware including laboratories, instrumentation, ships, aircraft, satellites, moored platforms, autonomous vehicles, high performance supercomputing, test beds, proving grounds, data repositories, computer models and information systems. To sustain this R&D infrastructure, NOAA will prioritize infrastructure investments based on a corporate view of mission needs and R&D.

Workforce excellence: A creative and vibrant scientific workforce is at the core of NOAA's R&D and mission services enterprise. NOAA will seek to recruit, develop and retain a diverse scientific workforce in a range of relevant disciplines and provide opportunities for scientific staff to excel individually, as team members and leaders, and as mentors for the next generation of NOAA scientists, including those from underrepresented groups. Training and professional development will be made available such that the scientific workforce can adapt, expand beyond

traditional disciplinary boundaries and remain agile as mission needs change. Engagement with mission-relevant professional societies and communities of practice will be encouraged and rewarded.

Scientific integrity: Scientific research sponsored and conducted by NOAA catalyzes innovative breakthroughs, informs regulatory and policy decisions and enables the development of new industries. A robust scientific enterprise requires transparency, traceability, reproducibility and scientific integrity at all levels of practice and management. To maintain NOAA's place among the most trusted and credible sources of scientific information in the world, the NOAA R&D enterprise will embody both the NOAA Scientific Integrity Policy⁵ and the NOAA Plan for Increasing Public Access to Research Results.⁶

Accountability: NOAA's R&D enterprise must be corporate in scope, NOAA-wide, and with management, planning, and implementation integrated both vertically within responsible Line Offices and, as appropriate, horizontally across the Agency. The R&D enterprise will be regularly evaluated and adjusted based on objective reviews.⁷ Those responsible and accountable for R&D activities will be assigned authority to manage and direct the efforts. Accountability for NOAA's R&D portfolio rests with the NOAA Chief Scientist.

FY 18 NOAA Research Priorities:

In planning for FY18 and the out-years, NOAA corporate priorities remain: provide information and services to make communities more resilient; evolve the National Weather Service; invest in observational infrastructure; and achieve organizational excellence. A robust R&D enterprise is critical for meeting these priorities, and fulfilling NOAA's long-standing mission needs. When contemplating FY18 and the out-years, researchers, technology developers and managers at all levels of the Agency should review their current portfolios in light of the principles articulated in this guidance. When choosing among R&D projects and programs or developing R&D ideas for new investment, priority will especially be given to those investments that show a clear plan for transition to higher levels of mission readiness. The following areas merit further consideration, and are not listed in priority order:

⁵ The NOAA Scientific Integrity Policy is stipulated in NOAA Administrative Order 202-735D: Scientific Integrity and associated Handbooks.

⁶ The NOAA Plan for Increasing Public Access to Research Results and its associated directives are responsive to the Office of Science and Technology Policy 22 February 2013 Memorandum on Increasing Access to the Results of Federally Funded Scientific Research

⁷ The roles and responsibilities for R&D planning and management are defined in NAO 216-115, Strengthening NOAA's Research and Development Enterprise.

Integrated Earth System Processes and Predictions

NOAA has a broad set of predictive responsibilities, as reflected in its large and highly diverse modeling enterprise including models used for operational weather and ocean forecasting; global-scale models for climate research; predictions and projections over a range of time-scales; models used in hazard mitigation such as tsunami models and oil spill trajectory models; and biological and biogeochemical models for supporting ecosystem-based management of marine resources and ecological forecasting of marine hazards such as ocean acidification, hypoxia and harmful algal blooms. Models are essential tools for enhancing scientific understanding, making predictions and projections, and ensuring informed decision-making to meet NOAA's mission needs. Model development at NOAA depends on process understanding developed through targeted field and laboratory studies. NOAA will develop a unified modeling approach where best practices in process understanding, model development, data assimilation, post-processing and data dissemination are leveraged across disciplinary boundaries. Advancement and integration of NOAA's modeling capabilities will be pursued in three domains: targeted process studies; model resolution and scaling (in time and space); and model complexity.

Process Studies

The inherently complicated nature of earth systems dictates that NOAA must continue to enhance understanding of those processes that drive the variability of relevant natural parameters. NOAA's suite of earth system models depends on process understanding from field- and laboratory-based studies conducted internally, with partners and by the broader scientific community. Specific emphasis will be placed on those process studies that are targeted towards clearly articulated mission needs including model development and regulatory and management requirements.

Model Resolution and Scaling

The current scientific challenges of improving the accuracy of weather outlooks for weeks 3 and 4 and increasing the lead-time of severe storm outlooks fall in a skill gap between shorter-term weather prediction models and longer-range climate models. Building resilience in the face of climate variability and change requires information products and services at spatial scales much finer than those produced by most global climate models. There are a large number of science questions that need to be addressed to produce useful forecasts and outlooks within existing and planned high performance computing capacity. These include the atmosphere-ocean-cryosphere coupling strategy, statistical correction and calibration methods and downscaling, development

of scale-aware physics, extraction of information from ensemble forecasts and associated reforecasts, and evaluation of forecast value in the context of specific decision making tools.

Model Complexity

Assessing and understanding the role of ecosystem processes and biodiversity in sustaining ecosystem services in the face of anthropogenic stressors and climate variability and change require building additional complexity into models. NOAA will target significant advances in true integration of biological, chemical, geological and physical Earth system models, particularly to enhance ecosystem change detection and understand, model and predict impacts on habitat, living marine resources, and stewardship. Within coastal and nearshore waters, NOAA will pursue strategic approaches concerning scaling in order to incorporate regionally relevant coastal dynamics such as riverine flooding, sediment transport, and estuarine trophodynamics into models used to inform living marine resource management decisions.

Observing system optimization

Achieving the greatest possible outcomes from NOAA's existing and planned observing system investments as well as leveraging external investments is essential to achieving NOAA's strategic objectives. Observing system optimization requires targeted R&D, including: development of advanced technical methods for achieving traceable calibration and inter-calibration among NOAA and non-NOAA observing systems and sensors; development of methods to ensure sustained observations of climate-relevant variables; development of innovative advanced sampling technologies and associated statistical and analytical algorithms to improve living marine resource surveys and to provide complements to existing ship or aircraft based surveys; development of sensors to accelerate baseline characterization (chemical, physical and biological sensors); development and testing of new platforms (in-situ, remotely operated, etc); improvement of NOAA's capability to objectively assess the impact of potential future observing systems; and demonstration and evaluation of emerging atmosphere, ocean and coastal observation technologies.

Decision Science, Risk Assessment and Risk Communication.

Managing risk and resources demands a broad understanding of how people respond to scientific information and uncertainty and then make decisions. Meeting NOAA's strategic goals requires that the agency expand its capability in decision science, risk assessment and risk communication. This can be accomplished by incorporating research within and across a variety of social science disciplines such as psychology, economics, political science, sociology, and anthropology into the broad R&D enterprise. Key questions are how NOAA can best conduct

vulnerability assessments and how NOAA-supported resilience strategies can in turn address these vulnerabilities. Also of particular importance is research into innovative ways to develop, improve, and deliver tools that support real-time situational awareness and accurate comprehension of risk factors.

Data Science

The implementation of the Public Access to Research Results plan and NOAA's Big Data Project CRADAs provide both challenges and opportunities for extracting maximum utility from NOAA's vast and diverse data holdings. *Data science* within NOAA is focused on extracting useful information from complex collections of data that are often characterized by large degrees of heterogeneity, massive volumes, and rapid rates of collection. NOAA's data management capability would benefit from directed R&D into data curation, harmonization, integration and interoperability (platform and format independence). Within NOAA and working with our partners, tools to do this include high performance data access, storage and computing, cloud computing, data mining, natural language processing, machine learning and statistics all combined with accepted principles and theories in physics, chemistry, ecology, biology, and social science. As such, data science rests strongly upon the scientific process of analysis, hypothesis testing, uncertainty quantification, and repeatability. NOAA should leverage and investigate emerging developments in these areas to explore opportunities for data and information products, including reuse, that transcend disciplinary boundaries.

Water prediction

Predicting all aspects of the water cycle remains a critical national priority and key to evolving the National Weather Service and providing information and services to make communities more resilient. What are the key research and development challenges to enhancing and accelerating NOAA's ability to deliver reliable, actionable and timely information related to water on weather to climate timescales? How can the basic science of integrated hydrological and hydrodynamic modeling be improved across multiple physical and biological domains? How can we improve critical warning capabilities (e.g. flash flood)? How can we improve probabilistic forecasting and predictability of threshold risks, particularly seasonal and interannual forecasting of tipping points (e.g. drought intensification, natural resource stress points that induce human health and food supply concerns, etc.) that are useful for decisions and water resource management? With the likelihood of increasing demands for water resources and the changes in water availability due to a changing climate, how can water, ecosystem and socioeconomic interdependencies be adequately represented to improve our understanding of human-environment interactions and create fundamentally new modeling capabilities? How can we tackle critical observing system

challenges relevant to water cycle understanding, prediction and projection and the role of water vapor in global warming? How should we advance water cycle modeling and analysis tools that apply to assessments concerning water, including vulnerabilities of the interdependent systems, both human and ecosystem-based?

NOAA will develop a unified modeling strategy around water cycle understanding and prediction that aims to achieve organizational excellence in the development, deployment and use of NOAA's highly diverse modeling portfolio for providing products and services related to water. Aligning or integrating Great Lakes/ocean wave models, coastal inundation models and hydrology models is an immediate need.

Arctic

Climate change in the Arctic is making Arctic ecosystems more vulnerable while enabling maritime and industrial activities to expand. The need for environmental intelligence in the Arctic is increasing. Arctic observations are a critical gap. R&D to improve monitoring, understanding, prediction and projection of the Arctic environment remain a high priority. The present rate of sea ice loss, with its regional and global impact, creates an urgency to improve sea ice predictions at all time scales, from the short term (i.e., daily to weekly) to seasonal and decadal time scales. Dynamic changes in the coastal zone including changing coastal bathymetry, water levels, storm surge, inundation and erosion, are also threatening resources, but these coastal processes are not well understood. Arctic waters are particularly vulnerable to ocean acidification but the impacts on Arctic ecosystems are largely unknown. Weather and climate analysis and prediction capabilities are currently poorer in the U.S. Arctic than in other parts of the United States, due to sparse observations, particularly a lack of good physical data regarding winds and clouds. Changes in the physical and chemical characteristics of the Arctic Ocean will profoundly affect the biological communities for which NOAA holds stewardship responsibilities, and which are vital to the food security Arctic communities. Research into the impacts of Arctic changes on communities and ecosystems will focus on the development of information and services to make communities more resilient. Additional research is also needed on oil and dispersant toxicity impacts to arctic species as well as oil spill trajectories in ice-covered waters. For further guidance on Arctic priorities for R&D, the NOAA research community is encouraged to review NOAA's Arctic Vision and Strategy (2011), the NOAA Arctic Action Plan (2014), and the findings from the May 2014 NOAA Science Challenge Workshop: Predicting Arctic Weather and Climate and Related Impacts—Status and Requirements for Progress. The IARPC Five Year Research Plan also provides significant guidance.

